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THE CONTROL OF DUST-BORNE STREPTOCOCCAL INFECTION IN MEASLES WARDS

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Hospital trials on the control of dust-borne infection by oiling blankets, ward linen, garments, and floors were carried out in scarlet fever and measles wards in this hospital during the spring of 1942 and of 1943. The work in a scarlet fever ward, while on the whole encouraging, awaits the result of further tests before being recorded. The results of a controlled test in two measles wards are now reported.

The haemolytic streptococcus has for many years been recognized as a predominant secondary invader in measles and as an important cause of its serious complications—e.g., otitis media, mastoiditis, and bronchopneumonia. The virus-damaged mucous membrane of the respiratory tract, the catarrhal nature of the primary infection, and the overcrowding of patients in hospital at epidemic times all combine to favour the acquisition and spread of streptococci. The incidence of otitis media among measles patients may be as high as 20% (Allison and Brown, 1936); and of the patients so affected as many as 30% may develop mastoiditis. The frequency and severity of its complications made measles an important infection among the camp diseases of the United States Army during 1917 and 1918 (Michie and Lull, 1928). Its most serious consequences were pneumonia, empyema, and otitis media, which in the majority of cases were due to haemolytic streptococci. Cole and MacCallum (1918) found that a haemolytic streptococcal throat-carrier rate of 11.4% among measles patients on admission to hospital had risen to 38.6% after 3 to 5 days in the wards and to 56.8% after 8 to 16 days. They concluded that the chance of developing post-measles streptococcal infection was increased by residence in hospital, and that the high incidence of pneumonia, and the resulting high mortality, were due in part to infection occurring within the hospital. The sequence of events has become clearer since Griffith (1934) extended his method for the serological typing of *Str. pyogenes*. Allison and Brown (1936) were thus enabled to make a survey in a measles ward. They took nose and throat swabs from 43 patients once weekly from admission to discharge, and appropriate swabs on the occurrence of any complication. By typing the strains of *Str. pyogenes* which they had isolated they showed that cross-infection with these organisms occurred in 22—i.e., 51.2%—of the 43 patients; and that of the patients thus cross-infected 13 developed complications as a result (7 otitis media; 1 scarlet fever with otitis media; 1 rhinitis; 4 rise of temperature only). In other words, 19% of the measles patients developed otitis media consequent upon cross-infection with streptococci.

The work of Brown and Allison (1937) and of Cruickshank and Godber (1939) suggested that dust may be an important vehicle of haemolytic streptococci among patients with upper respiratory tract infections. These investigations revealed an increase in the number of streptococci in the ward air during bed-making and sweeping activities. Later, Thomas and van den Ende (1941) observed that in a ward containing tonsillitis cases both floor-sweepings and bed-clothes were heavily contaminated with haemolytic streptococci. Van den Ende, Thomas, and colleagues (van den Ende, Lush, and Edward, 1940; Thomas, 1941; Thomas and van den Ende, 1941; van den Ende, Edward, and Lush, 1941; van den Ende and Spooner, 1941; van den Ende and Thomas, 1941) investigated possible measures for the control of dust-borne infection in wards. The dust-laying effect of spindle oil when applied to floors was tested in field trials by Thomas, who found that the method produced a prolonged and marked reduction in the number of bacteria in the air during sweeping. Since, however, the main source of the bacteria-carrying particles lay in the bed-clothes, van den Ende and co-workers devised methods for the treatment of woollen and cotton materials with technical white oil, which reduced by 99% the number of micro-organisms liberated during bed-making. The method of oiling ward articles by the use of oil-in-water emulsions (van den Ende and Thomas, 1941) during the laundering process has been modified and made more practicable for large-scale application by Harwood, Powney, and Edwards (1944) of the British Launderers' Research Association. These workers describe their technique in an article at page 615 of this issue.

Scope of the Investigation

The purpose of this work was to find out if, in a measles ward, the oil treatment of floors, bed-clothes, linen, etc., would reduce: (1) the number of haemolytic streptococci in the air during sweeping and bed-making, (2) the incidence of cross-infection by haemolytic streptococci, (3) the incidence of clinical complications due to such cross-infection.

The work was undertaken for 12 consecutive weeks during March, April, and May, 1943, in two measles wards, identical in size, design, and aspect. In one—the Control Ward—no measures were taken against dust-borne infection. In the other—the Test Ward—the following measures were taken: during the first three weeks the floor was treated with spindle oil; during the subsequent nine weeks the floor was re-oiled every four weeks, and all blankets, counterpanes, sheets, pillow-slips, patients' garments, towels, gowns, white coats, curtains, etc., were treated with technical white oil during laundering. The blankets of each patient were disinfected after his discharge or transfer from the ward, and were washed and re-oiled every four weeks. The articles were oiled at the Laboratories of the British Launderers' Research Association. The bacterial content of the air, and the cross-infection and complication rate due to haemolytic streptococci, were studied in both wards throughout the investigation.

Ward Arrangements

1. The normal bed complement was 18 for each ward, and the normal spacing was 12 feet between bed-centres. During ten weeks of the investigation two extra beds, and during two weeks four extra beds, were put up in each ward, and the bed-spacing was correspondingly reduced.

2. So far as was practicable, patients were admitted alternately to the two wards.

3. Sulphonamides were given prophylactically to all patients unless there was any contraindication. During the first three weeks of the work a number of different drugs were used, in varying doses and for varying times. An intensive scheme was then introduced, and alternate patients admitted to each ward received sulphanilamide or sulphathiazole. The dosage, according to age, was 1 to 2 g. on admission, 3 to 7.5 g. daily for 3 days, followed by 1.25 to 3.75 g. daily till the day before discharge.

4. On admission prophylactic mixed scarlet fever and diphtheria antitoxin was injected into 54 (70.1%) of the 77 patients in the *Control Ward*, and into 56 (55.4%) of the 101 patients in the *Test Ward*.

5. Toys from both wards were periodically disinfected by heat. (During the later part of the work each patient in the *Test Ward* was allotted one toy, which was disinfected when he left. Had this plan of toy control been noticed earlier a similar method would have been adopted in the *Control Ward* also.)

6. Mattress, pillows, and blankets of each patient were disinfected in the hospital steam disinfector (5-lb. pressure for 30 minutes) on his discharge or transfer from the wards.

7. Patients with suppurative otitis media, if retained in the wards, were barrier-nursed. Feeding and sanitary utensils used by these patients were disinfected after use.

Routine Procedure

Air Sampling.—The bacterial content of the ward air was investigated by means of a slit sampler (Bourdillon, Lidwell, and Thomas, 1941). At intervals of 7 to 14 days air samples were taken in each ward during the early morning bed-making and sweeping times. The machine, on a trolley, was moved from one bed to the next as each in turn was made. During sweeping the machine remained at a central position in the ward. The height of the slit, through which air was drawn at the rate of one cubic foot a minute, was four feet from the floor. For measuring the total bacterial content of the ward air blood-agar plates were exposed in the slit sampler for one to three minutes, and were incubated aerobically for 24 hours at 37° C. The number of bacterial colonies (and, if not overgrown, the number of haemolytic streptococcus colonies) was counted on each plate. On crowded plates only an approximate count could be made. The total volume of air sampled for total bacteria was 8 cu. ft. on each occasion during bed-making or sweeping. For measuring the haemolytic streptococcus content of the air gentian-violet blood-agar plates were exposed in the slit sampler for 5 to 15 minutes. The number of haemolytic streptococcus colonies on each plate was counted after 24 hours' incubation at 37° C. aerobically, and representative colonial forms were transferred to blood broth for subsequent serological typing by the slide-agglutination method of Griffith. The total volume of air sampled on each occasion for haemolytic streptococci was 50 cu. ft. during bed-making and 30 cu. ft. during sweeping.

Cross-infection Incidence.—At the start of the investigation nose and throat swabs were taken from all patients in both wards. Subsequently, swabs were obtained from the nose and throat and from any suppurative lesion—e.g., ear discharge, impetigo—of every new patient, immediately *before* admission to the wards and then once weekly. Nose and throat swabs were taken from each member of the ward staff once monthly, and also on the development of any upper respiratory tract infection. Swabs were plated on gentian-violet blood-agar plates and incubated aerobically for 18 hours at 37° C. Representative colonial forms of haemolytic streptococci were tested for their serological type. Cross-infection was judged to have occurred if a patient, free from haemolytic streptococci on admission, acquired these organisms in the nose or throat; or if a patient who carried haemolytic streptococci on admission acquired haemolytic streptococci of different type in the nose or throat. In assessing the cross-infection rate the Type 6 streptococcus was adopted as the "indicator organism," since more than 90% of the cross-infections in both wards were due to this type. For completeness, however, all cross-infections with other serological types are recorded.

Complication Rate.—A daily round of all the patients in both wards was made and any complication or rise of temperature noted. Appropriate swabs were taken and plated on blood agar, and/or gentian-violet blood agar, and/or tellurite medium, according to the nature of the complication. Ear and mastoid swabs were investigated for the presence of haemolytic streptococci, pneumococci, staphylococci, and diphtheria bacilli. Any haemolytic streptococci isolated from patients with complications were tested for serological type.

Results of Investigation: Preliminary Period

During a preliminary period of three weeks the routine investigations were carried out in both wards. The only difference in dust control between the two wards during this time was that the floor of the *Control Ward* was unoiled, while that of the *Test Ward* was oiled.

Air Sampling.—Air samples were taken once weekly in each ward during the bed-making round. In the *Control Ward* the samples yielded respectively 103, 265, and 349 haemolytic streptococcus colonies per 50 cu. ft. of air. The high count of 349 on one occasion was largely due to one sample of 10 cu. ft. which yielded 177 colonies. All of 15 colonies tested serologically were Type 6. In the *Test Ward* the samples yielded respectively 149, 117, and 98 haemolytic streptococcus colonies per 50 cu. ft. of air. Thirteen of 14 colonies tested serologically were Type 6.

Cross-infection Rate.—At the start of the investigation 8 (36.4%) of the 22 patients in the *Control Ward* had Type 6 streptococci in the nose and/or throat; in addition one patient had Type 2 and one had Type 27 streptococci. During the preliminary period 16 (53.3%) of the 30 patients at risk (i.e., Type-6-negative either at the start of the period or on admission) acquired Type 6 streptococci in the nose and/or throat. In addition two other patients acquired Type 2 and Group C streptococci respectively. Seven (38.9%) of the 18 patients already in the *Test Ward* had Type 6 streptococci in the nose and/or throat; in addition one patient had Type "Impetigo 19," and one had Type 12 streptococci. During the preliminary period 18 (58.1%) of the 31 patients at risk acquired Type 6 streptococci in the nose and/or throat. In addition two patients acquired "type not determined" and Type 14 streptococci respectively.

Complication Rate.—During the preliminary period 7 patients out of 38 at risk in each ward developed middle-ear suppuration due to cross-infection with Type 6 streptococci. The ear-complication rate due to cross-infection was therefore 18.4% in each ward.

These results disclosed that conditions in the two wards were remarkably similar during the preliminary period. In both between 36 and 39% of the patients were harbouring the Type 6 streptococcus at the start of the work; in both the cross-infection rate with this type lay between 53 and 59%; in both the middle-ear complication rate, due to Type 6 streptococcus, was 18.4%; and in both numerous Type 6 streptococci were present in the ward air during bed-making.

Test Period

During the subsequent nine weeks the same investigations were continued in both wards. In the *Control Ward* no steps were taken during this period against dust-borne infection, whereas in the *Test Ward* the full measures of dust control—i.e., oiled floors, oiled bed-clothes, oiled garments, etc.—were maintained throughout. The change-over to oiled bed-clothes and other articles was accomplished in one day, and the floor was re-oiled on the same day.

Air Sampling.—Table I shows the results of air sampling at bed-making times in the two wards during the test period.

TABLE I.—*Counts of Total Bacteria and of Haemolytic Streptococci in Air during Bed-making in Control and Test Wards*

Ward	Date	Total Bacterial Colonies (approx.) developing per 8 cu. ft. of Air	Haemolytic Streptococcal Colonies developing per 50 cu. ft. of Air
Control	3/4/43	14,610	147
	15/4/43	15,540	131
	1/5/43	12,580	97
	13/5/43	5,240	218
	20/5/43	7,580	39
Test ..	26/3/43	1,120	7
	2/4/43	1,780	10
	9/4/43	1,013	2
	17/4/43	685	2
	30/4/43	1,845	0
	14/5/43	445	0
	22/5/43	390	0

Table II shows the results of air sampling at sweeping times in the two wards during the test period. Forty-eight colonies of haemolytic streptococci isolated from the air in the *Control Ward* were tested serologically; of these, 37 were Type 6. Eight colonies from the air of the *Test Ward* were typed, and all were Type 6. The reduction in the bacterial counts of the

TABLE II.—*Counts of Total Bacteria and of Haemolytic Streptococci During Sweeping in Control and Test Wards*

Ward	Date	Total Bacterial Colonies (approx.) developing per 8 cu. ft. of Air	Haemolytic Streptococcal Colonies developing per 30 cu. ft. of Air
Control	3/4/43	4,093	37
	15/4/43	15,260	34
	1/5/43	2,100	52
	13/5/43	1,500	9
	20/5/43	846	10
Test ..	2/4/43	226	1
	17/4/43	250	0
	30/4/43	810	0
	17/5/43	355	0
	22/5/43	315	0

air in the *Control Ward* towards the end of the experiment may have been due to two factors: (*a*) the improved weather and longer days, which allowed better natural ventilation; and (*b*) the reduction in the number of patients in the *Control Ward*, which during the last two weeks had a varying daily complement of 7 to 13, compared with 12 to 17 in the *Test Ward*.

Cross-infection Rate.—During the test period 30 (73.3%) of the 41 patients at risk in the *Control Ward* acquired Type 6 streptococci in the nose and/or throat. The infections were distributed regularly throughout the period. Cross-infection with other streptococcal types did not occur. During the test period 11 (18.6%) of the 59 patients at risk in the *Test Ward* acquired Type 6 streptococci in the nose and/or throat. In addition three other patients acquired Group A "type not determined," Group C, and Type "B 3264" streptococci respectively. The ward was never free from a source of the Type 6 streptococcus, the number of patients harbouring this organism at any one time varying from a maximum of nine to a minimum of one. The time during which there was only one source present was eight days. The Type 6 cross-infections were distributed as follows: 2 in the last week of March, 2 in April, and 6 in May

Complication Rate.—During the test period 7 (14.3%) of the 49 patients at risk in the *Control Ward* developed middle-ear suppuration due to Type 6 streptococcus. During the same period 2 (2.8%) of the 72 patients at risk in the *Test Ward* developed middle-ear suppuration due to Type 6 streptococcus. The other cross-infecting strains caused no complications.

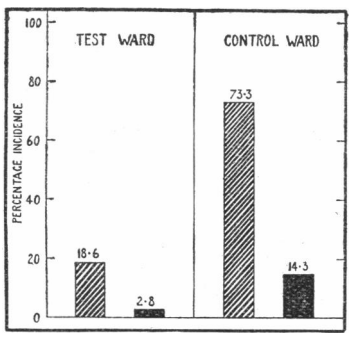

Chart showing cross-infection rate (cross-hatching) and middle-ear infection rate (black columns) due to Type 6 streptococci in (*a*) *Test Ward* with oiled bed-clothes, garments, and floor; (*b*) in *Control Ward* with no anti-dust measures.

Sources and Spread of Haemolytic Streptococci

Patients.—The Type 6 "indicator" streptococcus was well established at the beginning of the investigation. It was not possible to trace its origin, but its presence in both wards may have been due to the transfer of patients from one ward to the other a few weeks before this investigation began. Haemolytic streptococci of various other types were brought into both wards in the noses and throats of newly admitted patients. The carrier rate among new patients to the *Control Ward* was 18.2%, and to the *Test Ward* 12.2%. The type distribution, taking the two wards together, was: Group A, "type not determined," 4; Type 27, 4; Type 11, 2; Types 4/24, 6, 12, 13, 22, 28, "Impetigo 19," one each; Groups C and G, one each. One patient was admitted to the *Control Ward* and two patients to the *Test Ward* with streptococcal otorrhoea. Two of these (one with Type 1 and one with Type 6) were removed from the wards after a few days. The third (Type 22) was nursed in the *Test Ward*. There was no evidence that strains of streptococci in the upper respiratory tracts of new patients spread to other patients in the wards during the period of investigation.

Convalescent patients may become cross-infected after they are allowed up. Thus 5 of the 11 cross-infections in the *Test Ward* were first discovered in the swabs taken on the morning of the patients' discharge from hospital. Apparently they acquired the infection during convalescence by "visiting" infected patients in the ward.

Ward Staff.—Haemolytic streptococci were isolated from five members of the staff in the *Control Ward* at the routine swabbing. The type distribution was: Group A, "type not determined," 3; Type 6, 2. The two nurses with Type 6 streptococci developed sore throats. Haemolytic streptococci were isolated from four members of the *Test Ward* staff, with the following distribution: Type 6, 2; Types 12 and 25, one each. From time to time fingers of the ward staffs were swabbed, and it was not uncommon to find haemolytic streptococci upon them.

Ward Articles, Toys, etc.—Haemolytic streptococci, often in large numbers, were grown from toys, magazines, baths, tablecloths, bibs, spoons, tables, floors, etc., in both wards.

Nasal Toilet.—This was performed with cotton-wool rolled at the bedside on to wooden applicators. Petroleum jelly from a common pot was spread on the lips and face with the fingers. Numerous haemolytic streptococci were found in the petroleum jelly, and, as already mentioned, these organisms were also found on the nurses' fingers.

Chemoprophylaxis and Sulphonamide Resistance

Streptococcal cross-infections and their resulting complications occurred in spite of the fact that prophylactic sulphonamides were given to the majority of the patients in both wards. Of the Type 6 cross-infections, 37 of the 46 (80.4%) in the *Control Ward* and 20 of the 29 (69%) in the *Test Ward* were contracted while the patients concerned were receiving these drugs. A possible explanation of the ineffectiveness of chemoprophylaxis in preventing the spread of Type 6 streptococci lay in the fact that these strains in both wards were, as shown by *in vitro* tests, sulphonamide-resistant.

Complications resulting from Cross-infection

All cases of otorrhoea and of mastoiditis which developed after admission in both wards were the result of Type 6 streptococcus cross-infection. Table III shows that other complications due to cross-infection by this type also occurred. It lists these together with the middle-ear complications. In

TABLE III.—*Nature and Distribution of Type 6 Streptococcus Complications in Control and Test Wards*

Ward	Nature of Complication	No. of Cases	
		Preliminary Period	Test Period
Control	S.O.M., unilateral or bilateral	6	4
	R.S.O.M., B. mastoidectomy and gastro-enteritis	—	1
	L.S.O.M. and L. mastoidectomy	—	1
	L. mastoidectomy and extradural abscess of middle fossa	1	—
	B. mastoidectomy	—	1
	Skin sepsis	3	1
	Conjunctivitis	1	—
	Sore throat	—	1
	Purulent rhinitis	—	1
	Rise of temperature only	1	—
Test	S.O.M., unilateral or bilateral	4	2
	R.S.O.M. and R. mastoidectomy	2	—
	R.S.O.M. and orbital cellulitis	1	—
	Ulcerated lip	—	1
	Scarlet fever	—	1
	Rise of temperature only	2	2

R. = Right. L. = Left. B. = Bilateral. S.O.M. = Suppurative otitis media.

the *Test Ward* five children developed dermatitis or erythema of the skin. The reactions, which were mild and quickly subsided, may have been caused by the oil-treated undergarments, since evidence of skin irritation was also observed among scarlet fever patients after wearing similarly oiled garments. This problem is being further investigated.

Discussion

The results demonstrated that most of the serious complications in the measles wards were due to haemolytic streptococcal cross-infection. At the start of the work there was a heavy load of streptococcal infection in both wards. Toys, books, baths, and other ward articles yielded these organisms in abundance; and more than a third of the patients harboured Type 6 streptococci in the upper respiratory tract. We found also in the preliminary period that this type spread to more than half of the new patients, and caused one in every five to develop suppuration of the middle ear.

For a number of reasons we chose to control dust-borne infection rather than that carried by other means. Haemolytic streptococci multiply, almost as if in artificial culture, on the susceptible mucous membranes of measles patients. The catarrhal character of the disease favours gross contamination of bed-clothes and garments, from which on movement infected dust particles are released into the air. The streptococci are then free to infect fresh patients or to reinfect those already affected. They also contaminate the ward dust, and rise into the air again during sweeping and dusting. Air samples showed that during bed-making the air was heavily charged with haemolytic streptococci and, to a less extent, during sweeping. In the busy measles wards there was a constant stir and therefore a steady contamination of the air. Contact and droplet infection could not be disregarded, but they appeared to be occasional risks only, compared with the day-and-night inhalation of infected dust particles.

A further reason for our attempt to control dust-borne infection was the fact that there were means available of reducing and, possibly, of eliminating it. The first method which we tried was the treatment of the *Test Ward* floor with spindle oil, but we quickly discovered that this by itself was not enough. During a three-weeks trial of this method the air during bed-making contained 100 to 150 haemolytic streptococci per 50 cu. ft., the cross-infection rate (58.3%) was rather higher in the *Test* than in the *Control Ward*, and the ear-complication rate of 18.4% was the same in both wards. These findings are not surprising if the paths of dust-borne infection are considered: upper respiratory tract ⟶ droplets and discharges ⟶ bed-clothes and garments ⟶ ward air during bed-making ⟶ ward dust ⟶ ward air during sweeping. Thus the application of dust-laying oil to floors breaks only the last link in the chain; it does not influence the first and main reservoir of infected dust particles—the bed-clothes and garments of infected patients. Our second method of attack, therefore, was directed at this earlier link in the chain. The marked reduction in the number of aerial streptococci and in cross-infection and complication rates which followed the oiling of all blankets, ward-linen, and garments has been recorded above. It was, of course, possible that a spontaneous waning of the streptococcal cross-infection in the *Test Ward* had coincided with the introduction of the full anti-dust measures, but it seemed unlikely, for a reservoir of the cross-infecting Type 6 streptococcus never failed in the *Test Ward*, and new patients were admitted at the rate of about one a day. Their susceptibility was shown by the fact that a high cross-infection rate with the same streptococcus prevailed in the *Control Ward* among new patients, drawn from the same population during the same period.

Although the cross-infection rate was greatly reduced in the *Test Ward* after the introduction of oiled bed-clothes and garments, the residual incidence of 18.6% was still too high to allow of complacency. For the further prevention of secondary streptococcal infection in a measles ward measures may be required against mediate infection by fingers, toys, petroleum jelly, etc., and against direct droplet spread by staff carriers or between new and convalescent patients. On the other hand, it seems reasonable to assume that a heavy load of streptococcal infection would have been averted had anti-dust measures been introduced at the opening of the ward, so that these precautions might by themselves have sufficed to prevent clinical complications.

Thus our results suggest that cross-infection in measles wards is mainly due to dust-borne streptococci, which can be controlled by the oiling of floors, bed-clothes, and garments, but not by the oiling of floors alone. However, experience of these new methods of dust control is as yet not sufficient to justify any final judgment on their efficacy, and they should not be pressed into routine service until their advantages and limitations are more fully explored. There seems good reason to believe that they would prove useful in controlling secondary bacterial infection among influenza patients who may have to be nursed in large open wards. Anti-dust measures might also be tried in institutions—e.g., residential schools and training establishments—where respiratory infections are apt to spread.

Summary

An investigation into the control of dust-borne haemolytic streptococci was carried out in two measles wards of identical design during the spring of 1943. In the *Test Ward*, during a three-weeks preliminary period, the floor alone was oiled. During a subsequent nine-weeks period bed-clothes, patients' garments, and all other woollen and cotton articles in ward use were treated regularly with emulsions of technical white oil, and the floor was re-oiled at intervals. In the *Control Ward* no anti-dust measures were taken. In both wards the air was sampled for total bacteria and for haemolytic streptococci during bed-making and sweeping, and the streptococcal cross-infection and complication rates were recorded and analysed. In assessing the cross-infection rate Type 6 streptococcus was adopted as the "indicator organism," since in the two wards it accounted for 90% of the cross-infections and for all the middle-ear complications occurring after admission.

In the *Test Ward*, while the floor alone was oiled the Type 6 cross-infection rate was 58.1%, compared with a rate of 53.3% in the *Control Ward*. In each ward the middle-ear complication rate due to Type 6 was 18.4%. Haemolytic streptococci were numerous in the air of both wards during bed-making, the predominant strain being Type 6. Thus oiling of floors alone was not sufficient to control the spread of dust-borne haemolytic streptococci in measles wards.

In the *Test Ward*, while the full anti-dust measures of oiled bed-clothes, garments, etc., and oiled floor were in force: (*a*) the mean haemolytic streptococcus count in the air during bed-making was reduced by 97.5%; (*b*) the mean bacterial count in the air during bed-making was 91% less, and the mean haemolytic streptococcus count 98% less, than in the *Control Ward*; (*c*) the mean bacterial count in the air during sweeping was 92% less, and the mean haemolytic streptococcus count 99% less, than in the *Control Ward*; (*d*) the Type 6 cross-infection rate was 18.6%, while in the *Control Ward* it rose to 73.3%; (*e*) the middle-ear complication rate due to Type 6 was 2.8%, compared with 14.3% in the *Control Ward*. Thus the oiling of all bed-clothes and ward-linen, in addition to the oiling of floors, effectively controlled dust-borne streptococcal infection in measles wards. Cross-infection from direct contact or mediate means was not prevented by anti-dust measures.

A high streptococcal infection rate occurred in spite of intensive sulphonamide prophylaxis. The cross-infecting Type 6 strain was found by *in vitro* tests to be sulphonamide-resistant.

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REFERENCES

Allison, V. D., and Brown, W. A. (1936). Ann. Rep. C.M.O. of Ministry of Health, Appendix A, London.
Bourdillon, R. B., Lidwell, O. M., and Thomas, J. C. (1941). *J. Hyg.*, Camb., **41**, 197.
Brown, W. A., and Allison, V. D. (1937). Ibid., **37**, 1.
Cole, R., and MacCallum, W. G. (1918). *J. Amer. med. Ass.*, **70**, 1146.
Cruickshank, R., and Godber, G. E. (1939). *Lancet*, **1**, 741.
Griffith, F. (1934). *J. Hyg.*, Camb., **34**, 542.
Harwood, F. C., Powney, J., and Edwards, C. W. (1944). *British Medical Journal*, **1**, 615.
Michie, H. C., and Lull, G. E. (1928). *History Med. Dept. U.S. Army in World War*, Vol. 9, Washington, D.C.
Thomas, J. C. (1941). *Lancet*, **2**, 123.
—— and van den Ende, M. (1941). *British Medical Journal*, **1**, 953.
van den Ende, M., Lush, D., and Edward, D. G. ff. (1940). *Lancet*, **2**, 133.
—— Edward, D. G. ff., and Lush, D. (1941). Ibid., **1**, 716.
—— and Spooner, E. T. C. (1941). Ibid., **1**, 751.
—— and Thomas, J. C. (1941). Ibid., **2**, 755.